AEROTHERMODYNAMICS OF DESCENT SPACE VEHICLES AT STRONG COUPLED RADIATIVE-GASDYNAMIC INTERACTION

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A number of future space missions include scenarios where radiative heating becomes important. To develop a prediction computational fluid dynamics (CFD) tools for re-entry flows where radiation is important, some major areas are addressed. Most significant of them are the following: (1) physical-chemical kinetics of high temperature dissociated and ionized gases, (2) transport properties of the gases mixtures, (3) spectral radiative properties of high temperature gases and low-temperature plasmas, (4) numerical simulation algorithms for prediction of non-equilibrium gas mixtures dynamics and radiation heat transfer in volumes of various geometry, (5) models of physical and chemical processes attendant interaction of gas flows and radiation with thermo-protection systems of space vehicles (including their thermo-chemical destruction, ablation, sublimation, etc.).

Three dimensional CFD code NERAT (Non-Equilibrium Radiation Aero-Thermodynamics – 3D) was created in IPMech RAS to solve strongly coupled radiation gas dynamic problems of aerothermodynamic prediction of space vehicles for Jupiter missions. The code is based on the following groups of governing equations: (*a*) the Navier-Stokes and continuity equations, (*b*) the equations of mass conservation of separate species, (*c*) the equation of energy conservation, including total and vibrational energy, and (*d*) radiation heat transfer equation (in multi-group approximation). The code contains also calculation code ASTEROID (IPMech RAS) for prediction spectral optical properties of high temperature gases of complex composition. All equations are formulated in curvilinear coordinate system corresponding to geometry of a space vehicle. Calculations are performed with using a multi block and multi grid computational technology on structured calculation meshes. Developed numerical simulation algorithm is based on the hybrid implicit-explicit method of the second order of accuracy.

The paper contains numerical simulation results which demonstrate good agreement of calculation data obtained of code NERAT with other experimental and numerical simulation data for Martian and Earth entry trajectories.